

Cue Reactivity in Adolescents: Measurement of Separate Approach and Avoidance Reactions*

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ABSTRACT. Objective: There were two specific goals for the current study: (1) to demonstrate that adolescents display drug-specific cue reactivity to alcohol and cigarette visual cues that varies based on drug-use history and (2) to test the unique contribution of adolescents' avoidance reactions to alcohol and cigarette cues, independent of approach/craving reaction. **Method:** Adolescents ($N = 143$; age 13-20 years; 58 males) with varied substance-use histories were recruited from school and community sites. Adolescents were presented with a series of alcohol, cigarette, and nondrug comparison visual cues and reported their approach/craving and avoidance reactions. They also completed individual difference measures related to their alcohol and cigarette use and experiences. **Results:** When adolescents were grouped according to their current alcohol or cigarette use (no use, low use, high use), increased

use of alcohol or cigarettes was associated with stronger reactions (increased approach, decreased avoidance) to cues for that substance but not to nondrug control cues. Simultaneous regression analyses demonstrated that after controlling for approach/craving reactions, avoidance cue reactions predicted unique and/or incremental variance in measures of alcohol and cigarette usage, recent change in patterns of use, alcohol expectancies, alcohol restraint and parental alcohol problems. **Conclusions:** Adolescents displayed robust alcohol and cigarette cue-specific reactions that varied systematically with their current use of these drugs. Across numerous clinically relevant individual difference variables, predictive power was greatly enhanced through the inclusion of both avoidance and approach reactions. (*J. Stud. Alcohol* 66: 332-343, 2005)

NUMEROUS THEORISTS have observed that repeated drinking or drug use in the presence of specific environmental stimuli, or *cues*, can lead to a set of conditioned responses when in the presence of those stimuli, responses that can be called *cue reactivity* (e.g., Abrams and Niaura, 1987; Carter and Tiffany, 1999; Drummond et al., 1995). The most common alcohol cue is the sight of the beverage itself in its usual container, the final common pathway for most drinking. Cue reactivity can be an important marker of alcohol problems in that such reactions are stronger for alcoholics than nonalcoholics (Cooney et al., 1984; Monti et al., 1987), are predicted by depressed mood and various beliefs (Rohsenow et al., 1992) and have been found to predict drinking after treatment for alcoholics (Drummond and Glautier, 1994; Monti et al., 1993, 2001; Rohsenow et al., 1994, 2001). More directly, many theorists have suggested that implicit and explicit reactions prompted by substance-related cues result from both positive and negative reinforcement mechanisms and play an important etiologic role in the development of substance use disorders (e.g.,

Baker et al., 2004; Curtin et al., in press; Robinson and Berridge, 1993). Finally, studies of alcohol cue reactivity have also led to the development of cue-exposure-based treatments (e.g., Drummond and Glautier, 1994; Monti et al., 1993, 2001; Rohsenow et al., 2001). Although numerous studies of alcohol cue reactivity have been conducted among adults in treatment for alcohol dependence, little is known about the alcohol cue reactivity of adolescents. Finding a methodology that reliably elicits alcohol cue reactivity in this population should result in the ability to use the methodology as heuristically as has been done for adults.

Modest but reliable relationships have been observed between exposure to alcohol cues through advertising and levels of alcohol use among adolescents, suggesting that alcohol cue exposure may affect motivation to use alcohol (Adlaf and Kohn, 1989; Martin et al., 2002). Research on tobacco advertising demonstrates a similar relationship between exposure to tobacco products in advertising and movies and smoking-related behaviors and attitudes among adolescents (Goldberg, 2003; Henriksen et al., 2003). Although it is possible that adolescents may display cue reactivity much like their adult counterparts, cue reactivity in adolescents has received relatively little attention.

Only two studies have directly examined cue reactivity among adolescents, one with alcohol and the other with cigarettes. Tapert et al. (2003) used functional magnetic resonance imaging to examine the brain response to alcoholic and nonalcoholic beverage cues in adolescents with

Received: August, 17, 2004. Revision: December 20, 2004.

*Research for this article was supported by grants from the National Cancer Institute (R01 CA80255) and the National Institute on Alcohol Abuse and Alcoholism (R01 AA09892).

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and without alcohol-use disorders. Consistent with similar research with adults, high school teens with alcohol-use disorders exhibited relatively increased activation in frontal and limbic structures in response to alcoholic beverage cues. In addition, degree of brain response was correlated with current level of alcohol use and self-reported desire to use alcohol. The second study presented adolescent smokers with videotaped smoking and neutral cues in counterbalanced order (Upadhyaya et al., 2004). Smokers reported more desire to smoke to cigarette versus neutral cues only when cigarette cues were presented first, reported more sense of control to smoking cues only when these cues were presented second and showed increased heart rate during the start of the smoking cues independent of order. The authors concluded that young smokers showed similar patterns of responding as adult smokers, but the effects were not particularly robust and were unusually dependent on order of cues, possibly due to subjects' low levels of nicotine dependence and short learning histories. Order effects make generalization of results to the natural environment somewhat problematic. Nevertheless, the results of both studies suggest that cue reactivity may develop during adolescence and that there are meaningful relationships between reactivity and patterns of alcohol and cigarette use.

Conflict between approach and avoidance reactions

Individuals with alcohol- and drug-use disorders appear frequently to experience conflict between competing behavioral options (i.e., conflict between concurrent approach/craving and avoidance reactions with respect to substance use) and consistently to resolve that conflict in a maladaptive manner (i.e., continued alcohol use despite adverse consequences). Consistent with this, early models of alcoholism (Astin, 1962; Heilizer, 1964) used classic conflict theory (Miller, 1944) to understand the behavior of problem drinkers. These models suggested that cues associated with alcohol elicit an approach-avoidance conflict in problem drinkers, because alcohol use in response to these cues has been both rewarded and punished in the past. More recently, numerous researchers have argued that conflict or ambivalence about drug use and the associated maladaptive decision-making should be the basis of the definition of addictive behavior (e.g., Breiner et al., 1999; Heather, 1998; Peoples, 2002). Moreover, these conflicting motives are clearly observed in the diagnostic criteria for substance dependence (e.g., persistent desire for the substance despite efforts to cut down or control its use), and recent intervention models suggest assessment of these conflicting motives is critical to understanding motivation and behavior change processes (Prochaska et al., 1997; Miller and Rollnick, 1991).

To date, a handful of cue reactivity studies have provided initial support for the potential importance of simul-

taneous assessment of approach and avoidance reactions to alcohol and other drug-related cues. For example, Greeley and colleagues (1993) assessed social and problem-drinkers' responses to in vivo alcohol cues with a single bidirectional scale with anchors on each end that reflected the strength of approach/craving versus avoidance cue reactions. Results suggested qualitatively different self-report and physiological cue reactivity patterns among problem drinkers who reported primarily approach versus primarily avoidance reactions. However, their single bidirectional scale prevented the independent examination of approach and avoidance reactions, leading these researchers to conclude that future studies explicitly assess approach and avoidance on separate scales.

Following this recommendation, Avants and colleagues (1995) demonstrated that subsequent to exposure to cocaine cues (in vivo and videotape cues), cocaine-dependent participants' approach and avoidance reactions varied independently, suggesting that these scales do indeed tap separable reactions. Moreover, these researchers further categorized participants who reported increased approach/craving to cocaine cues into two groups: "Crave Only" (no change in avoidance) and "Crave + Disinhibit" (decreased avoidance). The Crave + Disinhibit group reported the lowest self-efficacy scores and highest obstacles to abstinence scores in the entire sample.

Most recently, Stritzke and colleagues (2004) assessed approach and avoidance reactions to photographic alcohol, cigarette and comparison (nonalcoholic beverage and food) cues in individuals with varied experience with alcohol and cigarettes. Regression analyses demonstrated that avoidance reactions contributed independent or incremental variance after controlling for approach reactions when predicting frequency and quantity of alcohol and cigarette use and efforts to restrain use. Similarly, cigarette cue avoidance reactions also predicted unique variance in nicotine-dependence status. Neither of the two adolescent cue reactivity studies conducted to date (Tapert et al., 2003, Upadhyaya et al., 2004) explicitly measured approach and avoidance cue reactions. However, these data highlight the potential import of this measurement technique.

The current study

There were two specific goals for the current study: (1) to demonstrate that adolescents display drug-specific cue reactivity to alcohol and cigarette visual cues that varies based on drug-use history and (2) to test the unique contribution of adolescents' avoidance reactions to alcohol and cigarette cues, independent of approach/craving reaction. To accomplish these goals, photographic images depicting alcoholic beverages, cigarettes and control cues (food and nonalcoholic beverages) were presented to adolescents with varied histories of alcohol and cigarette usage (no use, low

use and high use) for each substance. Adolescents' self-reported approach and avoidance reactions to these cues were independently assessed.

Method

Participants

Participants were 143 (58 male) adolescents recruited from several school and community sites. The mean (SD) age of the participants was 16.8 (1.2) years old (range: 13-20). The sample was predominately white ($n = 123$; 86%). Forty-four adolescents (31%) reported no lifetime alcohol use (i.e., maximum lifetime consumption of less than one drink). With respect to current alcohol use, 92 adolescents (64%) reported no alcohol consumption in the past month. The remaining 51 participants (36%) reported a mean consumption of 16.9 (17.9) drinks (median = 10; range: 2-70) in the past month. With respect to current cigarette use, 119 adolescents (83%) reported no cigarette use in the past month. The remaining 24 participants (17%) reported a mean consumption of 49 (68.9) cigarettes in the past month (median = 3.5; range: 1-240).

Materials

Thirty substance-cue slides were included to represent three substance categories: alcoholic beverages (8 slides containing beer and 4 slides containing hard liquor), tobacco cigarettes (6 slides) and control cues (6 food and 6 nonalcoholic beverage slides). The slides were developed to represent typical adolescent drinking scenes (e.g., refrigerator/cooler full of beer, beer on table with cards or other paraphernalia to suggest a drinking game, drinkers outside or in the back seat of car). Slides for the cigarette and control categories were selected from a comparable and previously validated set of substance cue slides that were developed for a similar purpose (Normed Appetitive Picture System; Stritzke et al., 2004). Slides included both active (e.g., beer pouring, orange juice pouring, cigarette burning in ashtray) and still images (i.e., unopened cans of beer, cans/bottles of cola, unlit pack of cigarettes). Brand names and identifying symbols were excluded from most slides to reduce response variability due to brand preference. When brands were discernable, more than one brand of the substance was included in the slide. To avoid contamination of substance-cue response by reactions to affective information conveyed by people displayed in the slide, people were excluded from the majority of slides. For slides in which people were present, facial expressions and body posture were kept neutral. Two separate slide presentation orders were created to avoid slide order and/or fatigue effects. In each order, cues for each substance category were intermixed and the average serial positions of alcohol, cigarette

and nonalcoholic beverage cues were equal. Order was included as a factor in initial analyses, but it did not interact with any of the reported effects. Therefore order was not included as a factor in the final analyses reported below.

Procedure

All participants provided parental consent and signed study assent forms prior to participation. All study data were collected in private conference rooms or classrooms at each of the testing sites. Seating was spaced to provide privacy for participants' responses. Each testing session began with the presentation of standardized instructions by the experimenter. Participants were told that the purpose of the study was to examine reactions to pictures of common habits such as eating, drinking and smoking. To encourage honest and accurate responses, participants were informed that their responses would not be shared with others. Detailed instructions and practice using the approach and avoidance rating scales were provided. The slide-ratings task was initiated after completion of these instructions. Each slide viewing trial began with a 4 s presentation of a preparatory slide that served to focus participants' attention on the slide screen. Substance cue slides were each presented for 6 s, followed by a 20 s rating period. The subsequent preparatory slide signaled the conclusion of the current rating period. Following the slide-rating task, participants completed the individual differences questionnaires.

Measures

Substance cue reactivity ratings. Self-reported approach/craving and avoidance reactions were collected during each substance cue slide presentation. Approach was defined as the desire to consume the item in the slide (i.e., "How much do you want to consume the previous item right now?") It was emphasized that this was *not* the same as the belief that they would actually consume the item, because they might find that they desire the item while at the same time being determined to not give in to the desire for various reasons. Avoidance was defined as the feelings of restraint or desire to avoid consuming the item depicted (i.e., "How much do you want to avoid consuming the previous item right now?") despite any feelings of craving that might also be experienced. Each approach and avoidance reaction was rated on separate 9-point scales with low and high anchors of "not at all" (0) and "very much" (8), respectively. To reduce the possibility of rating errors, approach reaction was rated first, followed by avoidance, for each substance cue. Overall approach/craving and avoidance reactions for each substance-cue category (i.e., alcohol, cigarette, control cues) were calculated by averaging discrete ratings across multiple individual cue presentations. The internal consistency (i.e., Cronbach's alpha) for approach

and avoidance ratings for alcohol and cigarette cues was quite high (range: 0.96-0.98). Not surprisingly, the internal consistency of ratings for control cues was somewhat lower (0.65 and 0.69 for approach and avoidance, respectively) because of the greater variability in specific content within this substance category.

Individual difference questionnaires. Participants completed a set of self-report demographic and individual difference questionnaires. Lifetime indices of total drinking days and maximum number of drinks in one day were collected. Past month estimates of total quantity (i.e., number of drinks) of alcohol consumed, number of drinking days and number of days intoxicated were also measured. In addition, adolescents were asked to report if their current (past month) frequency and quantity of alcohol use had increased, decreased or remained the same relative to one year ago. For all questions involving quantity of consumption, adolescents were instructed that "an alcoholic drink can be either a 12 oz beer, a 5 oz glass of wine or a 1.5 oz shot of hard liquor (straight or with a mixer)." Information about past month cigarette use (number of days and cigarettes/day) and lifetime cigarette use was also obtained.

Problems associated with alcohol use in the past year were assessed with the Rutgers Alcohol Problems Index (RAPI; see White and Labouvie, 1989, for construct validity; Cronbach's alpha = 0.91 in this study). Alcohol expectancies were evaluated with the Comprehensive Effects of Alcohol (CEOA) questionnaire (see Fromme et al., 1993). The CEOA questionnaire has been validated for use with adolescents (Fromme and D'Amico, 2000) and yields seven scales indicating alcohol-effect expectancies for sociability, tension reduction, liquid courage, sexuality, cognitive and behavioral impairment, risk and aggression, and negative self-perception. Cronbach's alphas ranged from 0.66 to 0.88 across CEOA scales in this study. Drinking restraint was measured with the Temptation and Restraint Inventory (TRI; Collins and Lapp, 1992), which yields five scales: govern (difficulty controlling drinking), emotion (negative affect drinking), cognitive preoccupation with drinking, restrict (efforts to reduce consumption) and concern about drinking. Cronbach's alphas ranged from 0.58 to 0.84 across TRI scales.

Parental drinking problems were assessed with separate father and mother versions of the 13-item Short Michigan Alcohol Screening Test (F-SMAST and M-SMAST; Sher and Descutner, 1986). Adolescents were instructed to complete parent SMASTs only if they lived with the biological parent. Therefore, a reduced sample was available for these two measures ($n = 85$ and 115 for F-SMAST and M-SMAST, respectively). Cronbach's alpha was 0.76 and 0.47 for father and mother SMAST, respectively. The lower reliability for the mother SMAST resulted from no variance (i.e., endorsement of no problem for mother) on eight of the 13 items across all adolescents.

Results

Specificity of cue reactivity by substance use history

Analyses followed recommendations designed to strengthen validity of interpretations of observed differences in cue-elicited responding (see Robbins and Eherman, 1992; Stritzke et al., 2004). Participants were first grouped according to their level of current use of a particular substance (i.e., alcohol, cigarettes). Next, Current Substance Use (no use, low use, high use) \times Cue Content (alcohol, cigarette, control) analyses of variance (ANOVAs) were conducted for approach and avoidance ratings separately. Ideally, level of current drug use should affect cue-responding to that particular drug (e.g., current alcohol use should predict alcohol approach rating) but not the other psychoactive substance (e.g., cigarettes) or control cues (food and nonalcoholic beverages). Support for this specificity of reactivity is formally established by the observation of significant Current Drug Use \times Cue Content interactions. Huynh-Feldt corrected p values are reported for all effects involving the three-level within-subject Cue Content factor to control for potential violations of sphericity. Partial η^2 effect sizes are reported to index the magnitude of all effects.

Alcohol. To examine cue specificity for reactions to alcohol cues, participants were grouped according to their *current alcohol use*. Current alcohol use was indexed as the number of alcoholic drinks consumed over the past month. Ninety-two participants reported no alcohol use in the past month and were included in the "no alcohol use" group. Based on a median split for alcohol use among the remaining participants, 26 adolescents were included in the "low alcohol use" group (mean = 4.3 [2.9]; range: 2-10) and 25 were included in the "high alcohol use" group (mean = 17.6 [17.6]; range: 11-70).

Separate repeated-measures ANOVAs were conducted for approach and avoidance reactions with Current Alcohol Use (no vs low vs high alcohol use) as a between-subject variable and Cue Content (alcohol vs cigarette vs control cue) as a within-subject variable (see Figure 1). For *approach* reactions, the predicted Current Alcohol Use \times Cue Content interaction was observed ($F = 15.97$, $4/280$ df, $p < .001$; $\eta^2 = 0.19$). This indicates that the magnitude of the Current Alcohol Use effect on approach reaction varied across cue categories. Specifically, significant Current Alcohol Use effects on approach reactions were observed for alcohol cues ($\eta^2 = 0.27$, $p < .001$) and cigarette cues ($\eta^2 = 0.24$, $p < .001$) but not control cues ($\eta^2 = 0.04$, ns). However, as suggested by these effect sizes, the Current Alcohol Use Effect on approach reactions did not differ significantly across alcohol and cigarette cues ($F = 1.28$, $2/140$ df, $p = .376$; $\eta^2 = 0.01$).

For *avoidance* reactions, the predicted Current Alcohol Use \times Cue Content interaction was also observed ($F = 11.70$,

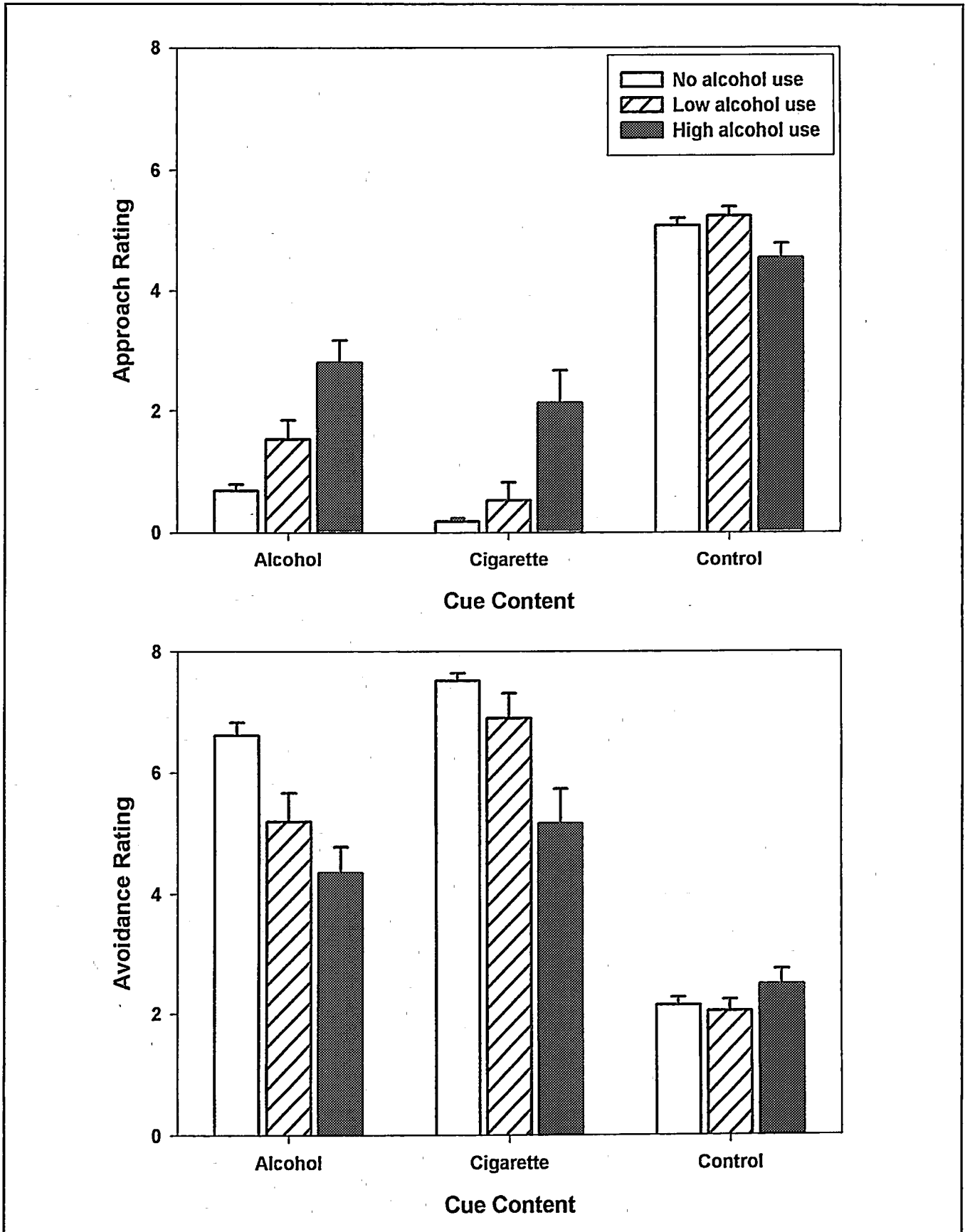


FIGURE 1. Mean approach (top panel) and avoidance (bottom panel) ratings by Current Alcohol Use and Cue Content factors. Error bars represent between-subject standard errors.

4/280 df, $p < .001$; $\eta^2 = 0.14$), indicating significant variability in the magnitude of the Current Alcohol Use effect on avoidance reactions across cue categories. Specifically, significant Current Alcohol Use effects on avoidance reaction were observed for alcohol cues ($\eta^2 = 0.16$, $p < .001$) and cigarette cues ($\eta^2 = 0.20$, $p < .001$) but not control cues ($\eta^2 = 0.02$, ns). The Current Alcohol Use effect on avoidance reactions did not differ across alcohol and cigarette cues ($F = 1.66$, 2/140 df, $p = .195$; $\eta^2 = 0.02$).

The lack of specificity in approach and avoidance reactions across alcohol and cigarette cues may have resulted from the sizable covariance between alcohol- and cigarette-use patterns in adolescents. Specifically, current alcohol and cigarette use were significantly correlated ($r = 0.45$, $p < .001$). To control for this, variation in cigarette use was held constant by conducting Current Alcohol Use analyses among the subsample of adolescents who reported no current cigarette use ($n = 119$). In this subsample, significant Current Alcohol Use \times Drug Cue Content (alcohol vs cigarette only) interactions of the predicted form were observed for both approach and avoidance reactions [$\eta^2 = 0.15$ and 0.12 , p 's $< .001$, respectively]. This indicates that the effect of Current Alcohol Use status was greater for alcohol than cigarette cues for both approach and avoidance reactions among nonsmokers.

Cigarettes. A comparable analytic strategy was used to examine cue specificity for reactivity ratings to cigarette cues (see Figure 2). Participants were grouped according to their Current Cigarette Use, indexed as the number of cigarettes consumed in the past month; 119 participants reported no cigarette use in the past month and were included in the "no cigarette use" group. Examination of the distribution for cigarette consumption among the remaining participants revealed a natural break at 12 cigarettes per month. Fifteen participants reported smoking between 1 and 12 cigarettes in the past month (mean = 3.3 [3.6]) and were included in the "low cigarette use" group. Nine participants reported smoking between 40-240 cigarettes in the past month (mean = 125.1 [56.6]) and were included in the "high cigarette use" group.

For *approach* reactions, the predicted Current Cigarette Use \times Cue Content interaction was significant ($F = 21.07$, 4/280 df, $p < .001$; $\eta^2 = 0.23$). Significant Current Cigarette Use effects on approach reaction were observed for cigarette cues ($\eta^2 = 0.62$, $p < .001$) and alcohol cues, ($\eta^2 = 0.09$, $p = .002$) but not control cues ($\eta^2 = 0.02$, ns). Moreover, as suggested by the effect sizes, the Current Cigarette Use effect on approach reaction was greater for cigarette than alcohol cues ($F = 16.23$, 2,140 df, $p < .001$, $\eta^2 = 0.19$).

For *avoidance* reactions, the predicted Current Cigarette Use \times Cue Content interaction was significant ($F = 16.36$, 4/280 df, $p < .001$, $\eta^2 = 0.19$). Current Cigarette Use effects on avoidance reactions were observed for cigarette cues ($\eta^2 = 0.45$, $p < .001$) and alcohol cues ($\eta^2 = 0.08$, $p = .004$)

but not control cues ($\eta^2 = 0.00$, ns). Moreover, the Current Cigarette Use effect on avoidance ratings was greater for cigarette than alcohol cues ($F = 20.56$, 2/140 df, $p < .001$, $\eta^2 = 0.23$).

Approach versus avoidance reactions and individual differences

Alcohol. A moderately strong negative correlation was observed between approach and avoidance reactions to alcohol cues among all adolescents ($r = -0.65$, $p < .001$) and the subset of adolescents who reported alcohol use in the past month ($n = 51$; $r = -0.57$, $p < .001$). Despite these relationships, the goal of the next analyses was to examine the degree to which avoidance reactions to drug cues were uniquely or incrementally related to measures of drug experience, after controlling for variance explained by approach reactions. To accomplish this, separate simultaneous regression analyses were performed for each drug-related individual difference measure. In each of these regressions, alcohol cue approach and avoidance reactions were included as predictor variables. Semipartial correlation coefficients for approach and avoidance reactions provide an index of each reaction's *unique* contribution to the prediction of each drug-related individual difference measure. See Table 1 for results from these regression analyses.

Semipartial correlation (sr) coefficients for approach reactions showed that increased approach to alcohol cues was associated with increased report of current and lifetime indices of alcohol usage. Avoidance reaction to alcohol cues was significantly and incrementally predictive of lifetime alcohol usage (increased avoidance associated with lower lifetime use) but not current alcohol use. In addition, avoidance reaction was significantly related to change in alcohol use patterns, with increased avoidance associated with decreased current frequency and quantity of alcohol use relative to previous use patterns. In contrast, the approach reaction to alcohol cues was not related to change in alcohol use patterns.

Avoidance reaction was uniquely associated with a number of alcohol outcome expectancies. Significant positive relationships were observed with risk and aggression and with negative self-perception, indicating that adolescents who expected these subjectively negative outcomes from alcohol use also reported greater avoidance to alcohol cues. Moreover, significant negative relationships were observed with tension reduction and sexuality, indicating that adolescents who expected these subjectively positive effects from alcohol reported less avoidance to alcohol cues. In contrast, approach reaction was not significantly related to any of the CEOA alcohol outcome expectancy scales.

Approach, but not avoidance, reaction was significantly positively related to the recent (over the past year) experience of alcohol-use-related problems. In addition, approach

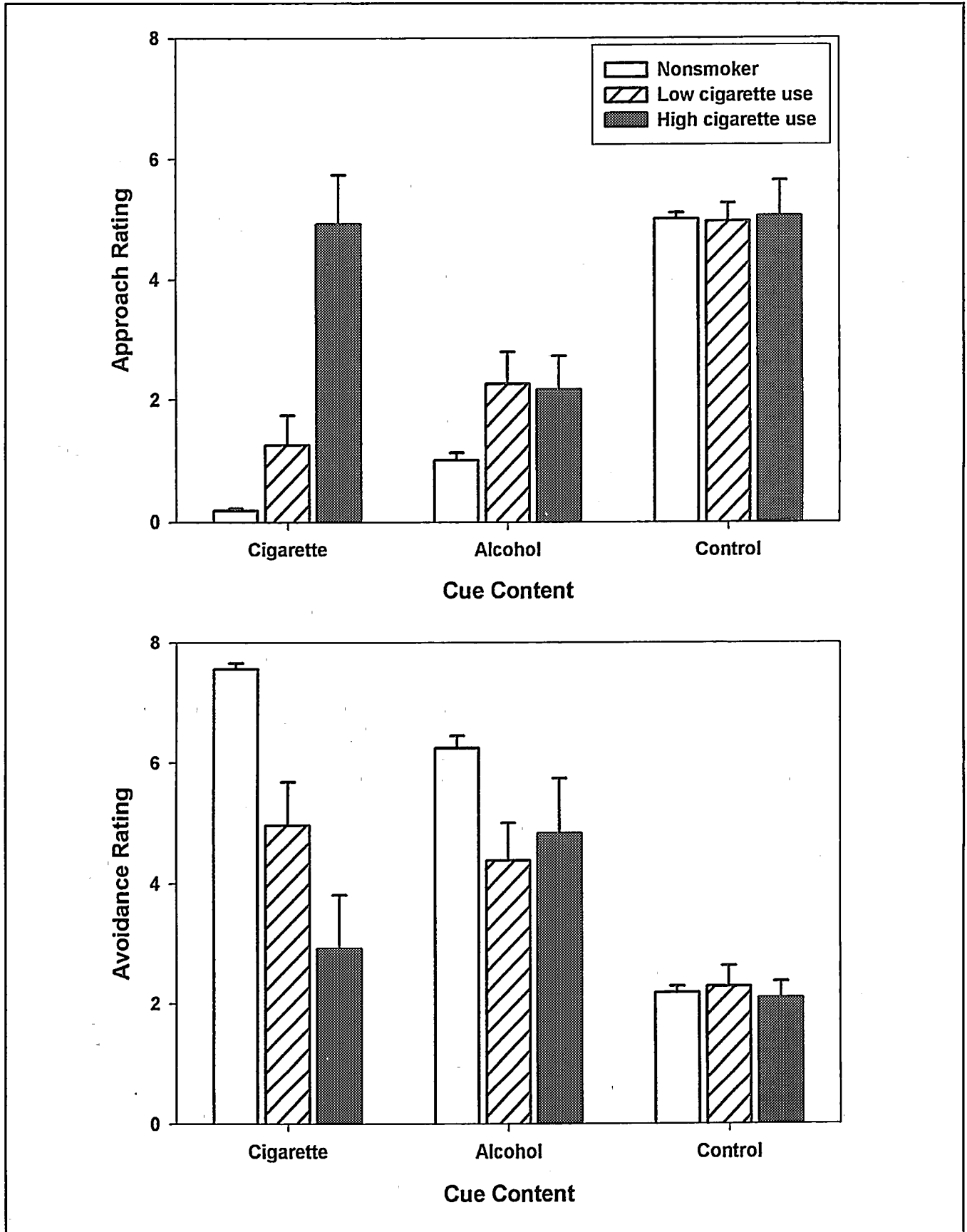


FIGURE 2. Mean approach (top panel) and avoidance (bottom panel) ratings by Current Cigarette Use and Cue Content factors. Error bars represent between-subject standard errors.

TABLE 1. Semipartial correlation coefficients from multiple regressions with each measure regressed on alcohol approach and avoidance ratings

Measure	Approach	Avoidance
Alcohol use level		
Drinking days (lifetime)	0.25 [‡]	-0.24 [‡]
Maximum drinks (lifetime)	0.24 [‡]	-0.25 [‡]
Drinking days (past month)	0.21 [†]	-0.04
Drinking quantity (past month)	0.30 [‡]	-0.10
Days drunk (past month)	0.27 [‡]	-0.09
Change in alcohol use patterns		
Increased frequency	0.05	-0.16*
Increased quantity	0.03	-0.21 [†]
Rutgers Alcohol Problems Index	0.48 [‡]	0.02
Comprehensive Effects of Alcohol Questionnaire		
Sociability	0.10	-0.15
Tension reduction	0.02	-0.22 [†]
Liquid courage	0.14	0.02
Sexuality	0.08	-0.44*
Cognitive and behavioral impairment	-0.11	0.14
Risk and aggression.	0.00	0.20*
Negative self-perception	-0.05	0.24 [†]
Temptation and Restraint Inventory		
Govern	0.19*	-0.12
Emotion	0.20*	-0.16*
Cognitive preoccupation	0.10	-0.13
Restrict	0.19*	-0.05
Concern about drinking	0.13	0.05
Parental alcohol problems		
Father SMAST	0.33 [†]	0.14
Mother SMAST	0.25 [†]	0.21*

Notes: In separate regression analyses, each measure was regressed on both alcohol approach and avoidance ratings. The table contains semipartial correlation coefficients from these regressions. Semipartial correlations index the unique effect of each rating variable (e.g., approach) after controlling for the other rating variable (e.g., avoidance). Squaring these coefficients provides the R^2 increase associated with adding that rating variable to a model already containing the other. Analyses of father and mother Short Michigan Alcohol Screening Test (SMAST) were limited to participants with the biological parent living in the home ($n = 85$ and 115 for father and mother SMAST, respectively). The full sample ($N = 143$) was used for all other analyses.

* $p < .05$; [†] $p < .01$; [‡] $p < .001$.

was significantly positively related to the govern, restrict and emotion scales of the TRI. Avoidance reaction was incrementally significantly related to emotion scale but no other TRI scale. Finally, significant positive relationships were observed between adolescents' approach reaction and parental (both mother and father) problems with alcohol. Avoidance reaction was incrementally positively related to the report of mother's alcohol problems, with the effect in the same direction but not significant for father's alcohol problems.

Cigarettes. A strong negative correlation was observed between cigarette approach and avoidance reactions among all adolescent participants ($r = -0.75$, $p < .001$) and the subset of adolescents who reported past month cigarette use ($n = 26$; $r = -0.71$, $p < .001$). Following previously reported analysis of alcohol cue reactions, each current cigarette use variable was regressed on cigarette approach and avoidance reactions. Despite their strong correlation, both

cigarette approach and avoidance ratings predicted unique significant variance in the typical number of cigarettes smoked per day in the past month. Greater approach reactions were associated with greater quantity on smoking days ($sr = 0.20$, $p = .001$) and greater avoidance reactions were independently associated with lower quantity on smoking days ($sr = -0.32$, $p < .001$). Only cigarette approach reaction significantly predicted number of days smoking in the past month ($sr = 0.50$, $p < .001$).

Discussion

This study was designed to advance understanding about drug cue reactivity through the examination of approach and avoidance cue reactions at an understudied but important developmental stage. Results indicated that adolescents display alcohol and cigarette cue-specific reactions that vary systematically with their current use of these drugs. Moreover, these alcohol and cigarette cue reactions do appear to be multidimensional, with avoidance reactions predicting sizable unique variance in many aspects of adolescent alcohol and cigarette use.

Drug cue-specific reactivity in adolescents

Study findings generally met the stringent criteria necessary to establish specificity in drug cue reactivity based on learning history (Robbins and Eherman, 1992). First, strong support for drug cue-specific reactivity to both alcohol and cigarette cues relative to control cues was obtained. In analyses of alcohol cue reactions, adolescents' alcohol approach and avoidance reactions differed significantly based on their current alcohol use. Comparable patterns of cigarette approach and avoidance reactions were also observed when adolescents were grouped according to their current cigarette use. In contrast, reactions to food and non-alcoholic beverage control cues did not differ across adolescents grouped by either their current alcohol or cigarette use. These analyses establish that adolescent alcohol and cigarette users exhibit increased cue reactivity relative to nonusers for both alcohol and cigarette cues. In addition, cue reactivity was specific to drug cues and not more generally observed to all cues (i.e., nondrug control cues) despite the fact that the control cues shared many of the critical properties of the drug cues (e.g., consumability, sensory modality, desirability).

To unambiguously conclude reactivity to a specific category of drug cues can be attributed to history of exposure to that drug, users of that drug must demonstrate greater reactivity to cues associated with that particular drug than to cues for other unrelated drugs (Robbins and Eherman, 1992). Such unrelated drug-cue comparisons are necessary to control for properties of drug cues (e.g., arousal) that are often quite difficult to match in nondrug control cues. With

respect to this second and more stringent criterion, clear support for cigarette cue-specific reactivity was documented as adolescents displayed cigarette cue-specific reactivity relative to both alcohol cues and nondrug cues.

Support for alcohol cue-specific reactivity in adolescents was also obtained, but this specificity appears to have been weakened because of significant covariation in cigarette usage across groups selected on current alcohol use. Initial crossover analyses in the full sample failed to demonstrate alcohol cue-specific reactivity relative to cigarette cues. Current alcohol use was associated with comparable changes in both alcohol and cigarette cue reactivity for approach and avoidance reactions. However, not surprisingly, significant overlap between levels of alcohol and cigarette usage was observed in these adolescents. When variation in cigarette usage was controlled by limiting alcohol use analyses to the large number of adolescents who reported no cigarette use in the past month, support for alcohol-specific reactivity was indeed obtained. This, in combination with the sizable changes in reactivity to alcohol versus nondrug control cues reported earlier, provides reasonable preliminary support to indicate that adolescents can develop specific alcohol cue reactions resulting from their history of exposure to alcohol. Future studies could further substantiate this conclusion by employing alternative designs that are not as sensitive to polysubstance use (e.g., arousal control design; Robbins and Eherman, 1992).

Unique or incremental contributions of avoidance reactions

Relatively strong support for the utility of the concurrent assessment of both approach and avoidance cue reactions was provided by the regression analyses that provided a test of the unique or incremental predictive contribution of each of the two cue reactivity dimensions, controlling for the other dimension. These analyses demonstrated the value of measuring avoidance reactions in cue reactivity studies. For example, although current level of alcohol use was predicted solely by alcohol cue approach ratings, the stability of adolescents' pattern of use was uniquely predicted by alcohol avoidance reactions. Alcohol avoidance reactions also accounted for incremental variance in lifetime alcohol use indices above that which could be accounted for by approach reactions alone. Similarly, alcohol avoidance reactions incrementally predicted various subscales on the TRI and parental (mother and, to a lesser extent, father) alcohol problems. Moreover, unique relationships between alcohol avoidance ratings and many alcohol outcome expectancies were observed. In contrast, approach reactions did not predict alcohol expectancies. Thus, across numerous clinically relevant individual difference variables, predictive power was greatly enhanced by including both avoidance and approach ratings.

Interestingly, across individual difference variables for which significant independent approach and avoidance ratings were observed (e.g., lifetime alcohol use indices, parental drinking problems), the direction of the effects varied. Contrary to what might be expected given theory and research on substance use ambivalence (e.g., Breiner et al., 1999; Stritzke et al., 2004), the partial correlations between approach and avoidance were in the same direction only for maternal (and to a lesser extent paternal) drinking problems. In other words, adolescents of parents with significant alcohol-related problems were more likely to report both increased approach and avoidance of alcohol cues. However, this pattern was not observed for other variables including lifetime alcohol use indices. Thus, it may be that adolescent's personal use may not be sufficient to prompt ambivalence, with such conflict only occurring after longer periods of use that are not obtained until adulthood.

Individual difference correlates of approach and avoidance reactions

Although many adolescents and college students display periods of heavy drinking, most do not develop persistent problems with their alcohol use. Instead, most young adults mature out of this pattern of use, reducing their heavy alcohol consumption without intervention (Bennett et al., 1999; Chen and Kandel, 1995; Schulenberg et al., 1996). However, some do continue to drink heavily, experience alcohol use-related problems and may escalate to alcohol abuse or dependence (Schuckit and Smith, 1996; Schulenberg et al., 1996; Vaillant, 1996). Researchers have highlighted the importance of determining the factors which facilitate adaptive change in drinking patterns among young heavy drinkers (Baer et al., 1995; Bennett et al., 1999; Gotham et al., 1997). In this context, it is of interest that avoidance reactions to alcohol-related cues were unique predictors of drinking behavior change in this study. Adolescents who reported higher avoidance scores were more likely to report that they had reduced both the frequency and the quantity of their alcohol consumption over the past year. In contrast, adolescents' approach reactions were not significantly associated with recent changes in alcohol use.

Given that alcohol avoidance reactions uniquely predicted reduction in alcohol use, it is important to examine factors that might affect the development of this avoidance reaction in adolescents. To start, it might be expected that previous experience of significant alcohol-related problems would lead adolescents to report some desire to avoid alcohol consumption when presented with alcohol cues. However, this does not appear to be the case. Approach reactions positively predicted RAPI scores, which likely reflects the negative outcomes that may result from strong alcohol approach tendencies. In contrast, RAPI scores were not predicted by avoidance reactions. Initially, the independence

of avoidance reactions and self-reported history of alcohol-related problems in younger drinkers appears somewhat counterintuitive. However, it is not without precedent in the literature. For example, Vik and colleagues (2000) observed that approximately two thirds of heavy-drinking college students failed to recognize a need to reduce their drinking despite the report of considerable problematic behaviors and negative outcomes resulting from their alcohol (e.g., fell behind in schoolwork, arguing with friends, risky sex, driving while intoxicated). In addition, using a similar methodology as that employed here, Stritzke et al. (2004) observed that avoidance ratings to alcohol cues were not predictive of alcohol-related problems in college students. Thus, the current study extends these observations to a developmentally earlier period during junior high and high school and suggests that behaviors and outcomes that might objectively be considered problems by adults may be less of a concern to younger drinkers.

Avoidance reactions were found to be significantly related to alcohol-related outcome expectancies. Adolescents who reported greater expectation of positive sexual or tension-reducing effects of alcohol reported decreased avoidance reactions to alcohol cues. Conversely, greater expectation about either increased risk and aggression or increased negative self-perception when intoxicated was associated with increased avoidance reactions to alcohol cues. In particular, these significant relationships between avoidance reactions and the latter negative alcohol outcome expectancies stand in striking contrast to the independence of avoidance reactions and actual experience of objective alcohol-related problems (RAPI scores). If adolescents expect negative outcomes when intoxicated, they will form avoidance reactions to drinking cues, but this negative expectation does not appear to result from experience of problems. In fact, RAPI scores were not significantly correlated with these latter two negative alcohol expectancies. These results suggest that additional research directed at understanding the factors that do affect the development of alcohol outcome expectancies may guide interventions that could increase avoidance reactions and subsequently decrease alcohol use in adolescents (Del Boca et al., 2002). Similarly, these results may help advance understanding of how procedures that involve alcohol expectancy challenge may ultimately affect alcohol use (Cruz and Dunn, 2003).

Statements about the causal ordering of the relationships between approach and avoidance cue reactions, expectancies, problems and use cannot be made in this cross-sectional data set. In fact, the relations among many of these variables are likely nonrecursive. For example, both positive and negative reinforcement learning in the context of substance use contributes to the initial development of approach and avoidance cue reactions, but these same reactions are believed to motivate further subsequent use (Baker et al., 2004; Curtin et al., in press). Tests of such causal

models must await other research designs. In particular, longitudinal research that tracks individuals from prior to initial alcohol or cigarette use through the development of stable patterns of use, problems and/or dependence would be particularly informative. More narrowly, research that explicitly manipulates alcohol expectancies can clarify their causal role in this larger framework (Del Boca et al., 2002).

It must also be acknowledged that the current sample was not recruited from a clinical setting and alcohol use/problems indices suggested that adolescents with formal alcohol-use disorders were not represented. That said, our results indicate that learning associated with even the limited experience with alcohol and cigarettes displayed by this sample produced strong effects on cue reactions. Future research must determine if the increased use and related experiences associated with the development of alcohol or nicotine dependence further strengthens or changes the pattern of these cue reactions.

The assessment of approach and avoidance reactions in this study relied on self-report methods. As a result, these measures reflect only participants' conscious levels of approach/craving and avoidance. Future research should include, and as necessary develop (i.e., for avoidance reaction), behavioral and psychophysiological indices of these constructs to allow for measurement of more implicit activation of these processes. In addition, it should be noted that each measure consisted of a single rated item. However, these ratings were obtained in response to numerous substance cues, which provided increased reliability relative to traditional single items measures of cue reactivity. In fact, as reported earlier, reliability of approach and avoidance ratings to substance cues was quite high.

Finally, cue reactivity research with both adolescents and adults would benefit from closer examination of the neural mechanisms that underlie drug use motivational processes. Substantial progress has been provided by the development of neuroimaging (Hommer, 1999; Tapert et al., 2003) and brain electrophysiological indices of craving (McDonough and Warren, 2001; Zinser et al., 1999). Of particular relevance, recent research has suggested that asymmetrical activation of frontal cortex may serve to index separate approach versus avoidance motivational processes (Harmon-Jones, 2003). Our results suggest that consideration of this multidimensional nature of cue reactions will likely advance understanding of the mechanisms responsible for the adaptive regulation of alcohol and other drug use.

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SOURCE: J Stud Alcohol 66 no3 My 2005

WN: 0512102128003

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